

MWI 8060.1

BASELINE

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MARSHALL WORK INSTRUCTION

ED01

OFF-THE-SHELF HARDWARE UTILIZATION IN FLIGHT HARDWARE DEVELOPMENT

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Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 2 of 16

DOCUMENT HISTORY LOG

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Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 3 of 16

1. PURPOSE

This Marshall Work Instruction (MWI) establishes a process for the utilization of Off-The-Shelf (OTS) devices originating from commercial vendors and military suppliers, as well as NASA hardware from other flight projects. Specifically excluded from this process are piece parts and materials, such as EEE parts, thermocouples, rivets, fasteners, connectors, fittings, adhesives, insulation, wiring, plumbing, etc. This MWI establishes a consistent method for design and development planning in accordance with MPG 8060.1, "Design Control," for incorporating OTS designs or hardware into flight hardware developments.

2. APPLICABILITY

This work instruction applies to all organizations incorporating off-the-shelf hardware into flight hardware developments.

3. APPLICABLE DOCUMENTS

MPG 8060.1, "Design Control"

4. REFERENCES

None

5. DEFINITIONS

5.1 Critical Application. Any application where a failure could cause loss of life or loss of mission.

5.2 Device. A combination of parts, structure, etc., usually self-contained, which performs a distinctive function in the operation of the overall equipment. A black box (e.g., transmitter, encoder, pump, fan).

5.3 Heritage. Refers to the original manufacturer's level of quality and reliability built into parts which have been proven by (1) time in service, (2) number of units in service, (3) mean time between failure (MTBF) performance, and (4) number of use cycles.

- High heritage - Hardware from the original supplier that has maintained the great majority of the original service, design, performance, and manufacturing characteristics.

Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 4 of 16

- Low heritage - Hardware that (1) was not built by the original manufacturer, (2) does not have a significant history of test and usage, or (3) has had significant aspects of the original service, design, performance, and manufacturing characteristics altered.

5.4 Modified OTS. An OTS device which has undergone a change in functionality, performance characteristics, or environmental operating conditions.

- Minimum modification - Does not change the basic functionality of the device from its original intended use, nor does it require the item to accommodate a significant difference in environments, nor significantly alter its operating parameters (i.e., does not compromise the heritage).
- Major modification - Changes either the functionality, performance, manufacturing process, environment, or a combination of these, of the device to a significant degree (i.e., the heritage is compromised).

5.5 Off-The-Shelf (OTS). Hardware that has an existing heritage and usually originates from one of several sources which includes commercial vendors as well as NASA and military suppliers. Categories include the following:

5.5.1 Commercial off-the-shelf (Designed and manufactured for commercial application).

5.5.2 Military off-the-shelf (Designed and manufactured for military use).

5.5.3 NASA off-the-shelf (Designed and manufactured for a NASA program other than the one for which the device is being proposed).

5.6 Significant. The term "significant" and its derivatives "significantly" and "to a significant degree" as applied to deviations of an off-the-shelf piece of hardware from its heritage or original design, or departure from its environmental qualification, must be determined by the application of sound engineering judgment by the project or the responsible design organization.

Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 5 of 16

6. INSTRUCTIONS

6.1 Requirements shall be developed and baselined by the project (including environments and operating conditions) prior to the start of the design phase of a project.

6.2 Utilizing these requirements, a survey of available OTS shall be made by the responsible design organization. The OTS identified during the survey for consideration shall be sorted into three categories: (1) meets all mandatory program requirements, (2) meets significant program requirements, or (3) meets few program requirements and is not normally a candidate.

6.3 The OTS which meets all mandatory requirements shall be considered a good candidate for selection.

6.4 OTS which meets significant program requirements shall be evaluated in the context of whether the program requirements can be relaxed to get agreement, or whether the OTS can be modified to meet program requirements and still retain a programmatic advantage over a new NASA development.

6.5 Early environmental and performance tests on sample OTS devices that verify vendor compliance with procurement specifications shall be performed, if appropriate. The extent of this testing will be determined by design based on the criticality of the application and the significance of any modifications performed and approved by the project. For critical applications, test or usage data shall be reviewed prior to final selection of the OTS device.

6.6 If the decision to utilize an OTS device in a flight development project is made, the project shall appropriately implement the requirements listed in Attachment 1. OTS application categories are identified in Attachment 2 for critical and non-critical hardware, as determined by the project manager. For each category the set of requirements from Attachment 1 which shall be applied is also identified.

6.7 At each design review, the OTS design shall be specifically evaluated to see if the proposed application is within the range of environments and operating conditions which are consistent with the OTS use experience and advertised specifications. This will include evaluation of advertised specification data, vendor test data if available, or the generation through NASA testing of additional data over the intended operating and environmental range.

Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 6 of 16

6.8 If the intended operation of an OTS device is outside the normal operating conditions or environments over which the device has demonstrated successful performance, then (1) an appropriate conservative design margin (i.e., derating) shall be applied by the responsible design organization for the intended use conditions and/or (2) a comprehensive test program shall be implemented to prove that the OTS design is acceptable. Since the OTS device is being operated outside its envelope, these extra measures will provide the confidence in the design that was not available through the empirical body of data that is implicit in repeated successful operations of a common design under normal environments and operating conditions.

6.9 For OTS utilized in a critical application several additional precautions shall be taken.

6.9.1 The OTS shall not be required to operate near the boundaries of its performance or environmental envelopes. To ensure this, specific margins shall be established during the requirements phase of the project and strictly adhered to during the selection of the OTS.

6.9.2 Prior to PDR and CDR, critical aspects of a design that utilizes OTS devices shall be identified and experts appointed to conduct an evaluation during the design reviews of each critical area identified.

6.9.3 Any subsequent design change which affects the design-review approved designs of the critical areas shall be reviewed by the same reviewers (if practical) prior to implementation.

6.9.4 The actual OTS modifications and the modification approach shall be developed jointly by NASA and the vendor, if practical.

6.9.5 OTS shall not be modified for a critical application unless adequate vendor design disclosure is obtained, or NASA reverse engineering is adequate for complete understanding of the OTS design.

6.10 The implementation of the requirements contained in Attachment 1, or exceptions thereto, for OTS utilized in critical applications shall be reviewed at each scheduled design review and approved by the review board chairman. For implementation of OTS in a non-critical application, the selected Attachment 1

Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 7 of 16

requirements, or exceptions thereto, shall as a minimum be reviewed and approved by the project manager.

7. NOTES

7.1 In order to select the appropriate requirement from Attachment 1, it is necessary to first categorize the NASA application of the OTS (i.e., how will the OTS be utilized?) This can be done in the following manner:

- Is the OTS intended for a critical or non-critical application, as determined by the Project Manager?
- Can the OTS be used as-is, or does it need to be modified, and by whom?
- What is the similarity of the manufacturer's intended performance and operating environments to those actually encountered in the NASA application?
- The combination of the three parameters identified above can be used to categorize the anticipated use of an OTS product. For example, an OTS product selected for a non-critical application, without modification, and within the manufacturer's specifications defines a category as shown in Attachment 2. For example, the category identified in this paragraph would require a minimum set of requirements to be applied (i.e. Items A&E).

7.2 The heritage of OTS hardware can be an indicator of the quality or reliability of OTS in a NASA application.

- High heritage does not exist on all OTS. An OTS device may have a low heritage due to limited production because of recent availability, low sales volume, unique application, etc.
- OTS design or manufacturing practices may not be acceptable despite the heritage of mass production. Inspection and/or test should confirm workmanship acceptability to the degree determined by the project manager to be appropriate for its application.
- OTS design margins should be verified with the vendor, determined by test, or an additional safety factor included, particularly for critical items.

Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 8 of 16

7.3 When NASA utilizes OTS hardware, unique acquisition issues may be encountered. The following examples have been identified:

- The project should ensure that the OTS hardware is purchased to work within the expected environment required by the application, and should obtain environmental specifications and/or test data from the vendor to confirm compatibility.
- OTS designers or manufacturers may not be sensitive to space environment issues like radiation, vacuum, thermal extremes, lack of convection cooling in zero-G, launch vibration, or enriched oxygen atmosphere; therefore, NASA should accept responsibility for assessing space environment compatibility.
- The manufacturer's configuration control of OTS products may not ensure all products are manufactured identically. OTS hardware manufactured at different times may have materials, parts, and manufacturing process differences. Whenever feasible, all OTS parts (including development test units and spares) should be purchased from a single lot to minimize material/part/process differences.
- OTS acceptance testing may need to be more comprehensive than the typical manufacturing defect screening tests, especially when the purchase of a single lot is not feasible. The more comprehensive acceptance testing should include workmanship as well as performance under expected use environments.
- If NASA is to become responsible for maintenance of the OTS device during its service life, this requirement should be addressed during procurement of the hardware to ensure that the total quantity of hardware required for the project is covered, including spares and replacement parts.

7.4 The modification of OTS design or hardware to be suitable for a NASA application affects its heritage.

- When OTS is modified, it is not true off-the-shelf anymore and its heritage is affected.
- When purchasing a modified OTS product, the modified hardware should be treated as a new design, and all appropriate processes associated with the design change should be reviewed.

Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 9 of 16

- NASA is not inherently qualified to work on or modify OTS hardware, so some vendor involvement is almost always required. Depending on the nature and degree of modification, the vendor may be the only one qualified to make the changes.

7.5 The decision to use OTS is generally considered by the program to be a smart decision.

- OTS designs must meet NASA requirements. This is more than functional similarity. NASA should develop good performance and environmental requirements for a potential OTS application and ensure that the OTS candidates are screened against this comprehensive set of requirements.
- When using OTS in a NASA-designed system, the interface requirements between the OTS and other hardware in the system should be properly defined so that the OTS is operated in accordance with the OTS manufacturer's performance and environmental specifications.
- The OTS heritage should be preserved to the maximum extent possible. Even simple-appearing modifications often compromise the OTS heritage.

8. SAFETY PRECAUTIONS AND WARNING NOTES

None

9. RECORDS

None

10. PERSONNEL TRAINING AND CERTIFICATION

None

11. FLOW DIAGRAM

See Attachment 3.

Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 10 of 16

12. CANCELLATION

None

Original Signed by

A. G. Stephenson
Director

Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 11 of 16

Attachment 1

Requirements List for OTS Product Usage

A. Meet the following requirements for all OTS usage

- Meet Safety Critical Requirements of Application (e.g., flammability, toxic offgassing, EMI emissions touch temperature, sharp edges, etc.)
- Perform Environmental Testing (if appropriate)(e.g., outgassing for vacuum use)
- Perform Vibration Testing - Workmanship
- Perform Thermal Testing - Workmanship
- Perform Detailed Inspection - Workmanship/Safety Audit (including destructive inspection of at least one unit, if required)

Note: The decision on the degree of inspection and testing required shall be made by the review board chairman or project manager, as appropriate.

B. Add the following requirements if OTS is modified or used in a critical application

- Conduct Performance Testing - Qualification
- Conduct Vibration Testing - Qualification (if appropriate)
- Conduct Thermal Testing - Qualification (if appropriate)
- Conduct Ionizing Radiation Testing - Qualification (if appropriate)
- Conduct Testing for Vacuum Use - Qualification (if appropriate)

C. Add the following requirements if OTS is in a critical application

- Add Margin to Requirements (de-rate the hardware)
- Evaluate Redundancy/Fault Tolerance Aspects of the OTS Design
- Acquire or Develop Reliability or Use Data to the Extent Required by the Application
- Qualify the Vendor as an Acceptable Source (ISO certification desirable)
- Buy All Units from the Same Lot if Practical, or Confirm Similarity by Inspection and Testing
- Acceptance Testing on all OTS and Qualification Testing on Modified OTS by NASA is Required (or government surveillance at the vendor)
- Obtain EMI Susceptibility Data (either test or analysis)

D. Perform appropriate analysis of OTS design

- Take Responsibility for Technical Validity of Any NASA Modification of OTS by Conducting Appropriate Analyses
- Acquire Design Details from Vendor of OTS Areas to be Modified by NASA
- If Applicable Vendor data is Unavailable, NASA Testing/Characterization Shall be Accomplished

Note: OTS shall not be modified for a critical application unless adequate vendor disclosure is obtained, or NASA reverse engineering is adequate for complete understanding of the OTS design.

Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 12 of 16

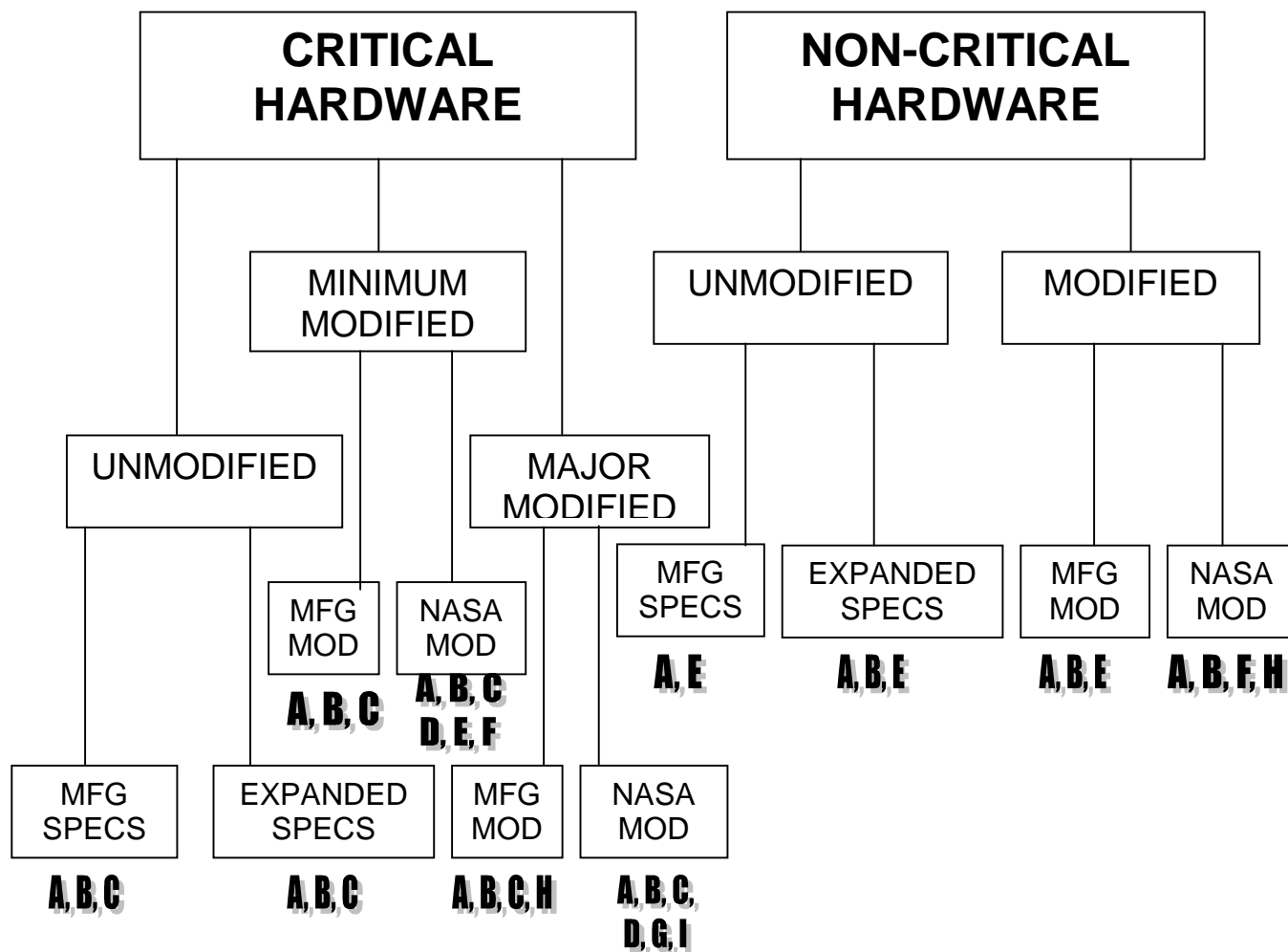
- E. Allow vendor to perform acceptance and/or qualification testing
- F. Supplier involvement in NASA modification is desirable
- G. Supplier involvement in NASA modification is required
- H. Design and/or test disclosure from the vendor is desirable
- I. Design and/or test disclosure from the vendor is required

Note: Design and test disclosure shall be sufficient to determine that the design approach for the modification to OTS hardware intended for a critical application meets all requirements and workmanship standards.

Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 13 of 16

Attachment 2

OTS Application Categories



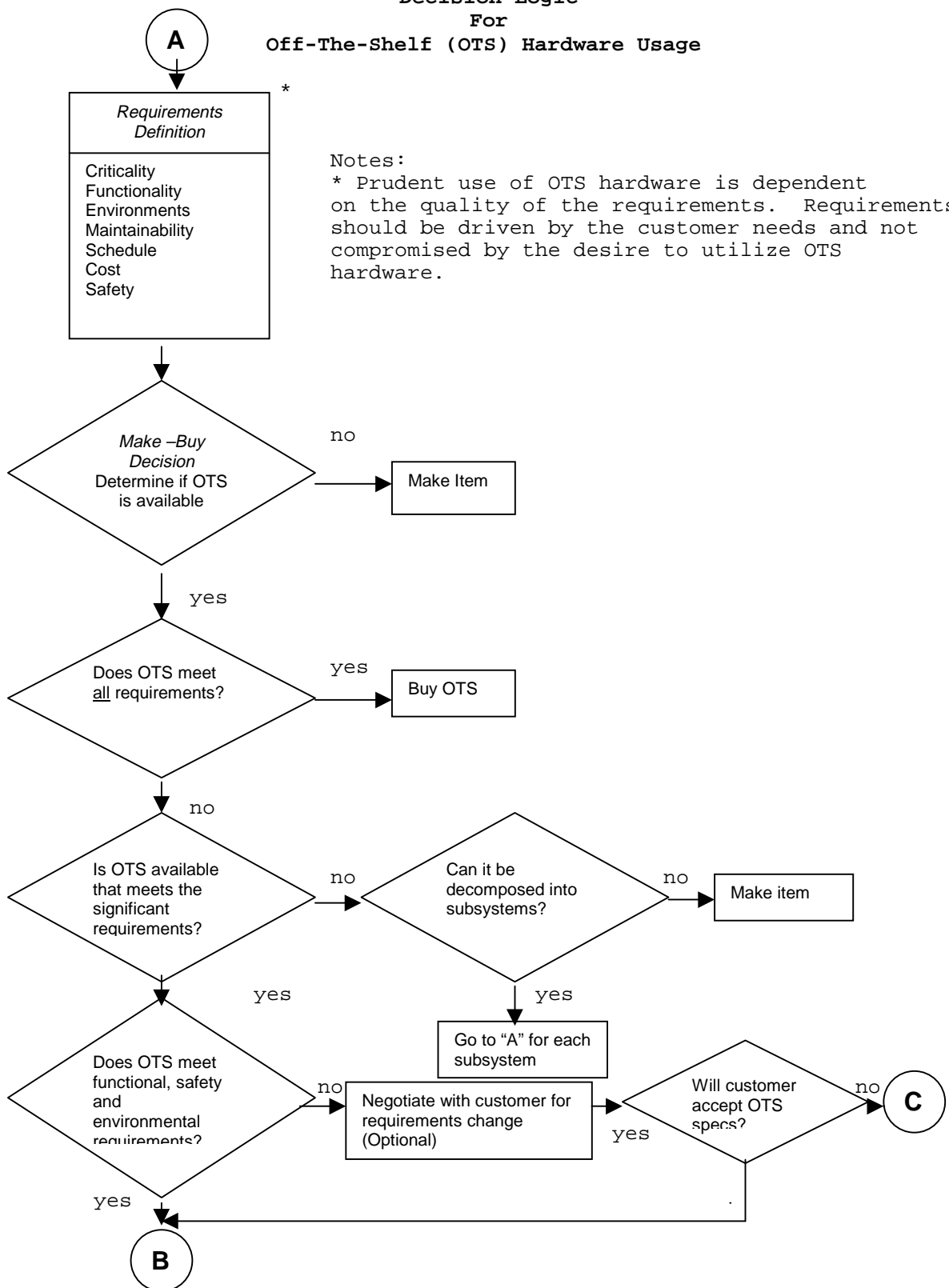
Note: See Attachment 1 "Requirements List for OTS Product Usage" for Contents of A, B, C, etc.

ACRONYMS
MFG - Manufacturer
MOD - Modifies
SPECS - Specifications
OTS - Off-the-Shelf

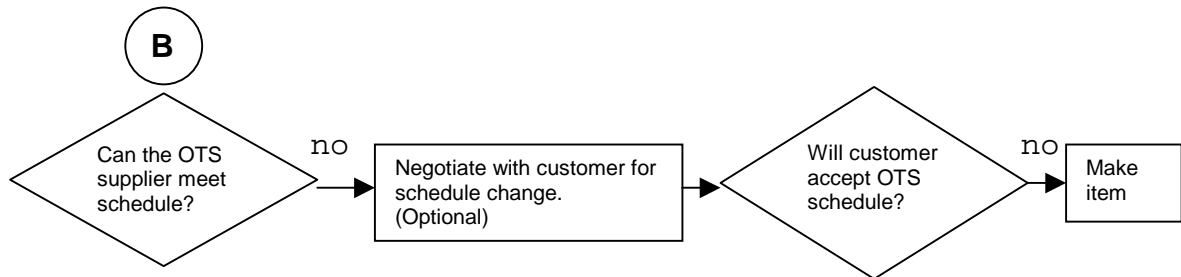
Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 14 of 16

Attachment 3
Decision Logic
For

Off-The-Shelf (OTS) Hardware Usage



Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 15 of 16



Marshall Work Instruction ED01		
Off-the-Shelf Hardware Utilization in Flight Hardware Development	MWI 8060.1	Revision: Baseline
	Date: August 3, 1999	Page 16 of 16

